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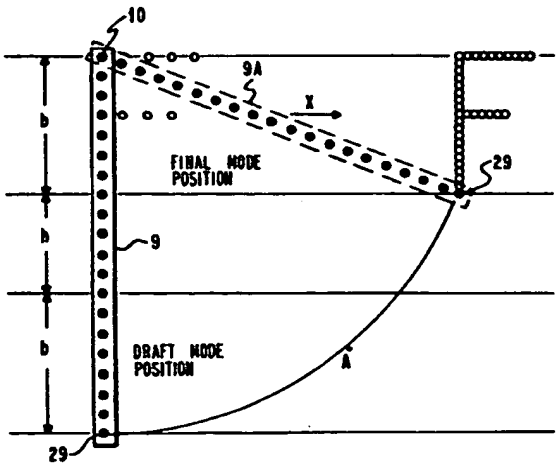
(54) Multiple mode printing system and method.

(57) A matrix print head (9) including a plurality of printing elements (10–29) arranged in one or more straight lines is mounted for lateral movement across a print line at more than one angle. In a draft mode of operation (9) the angle is chosen to provide a greater spacing between printing elements relative to the print line than is realized in a final, or quality mode (9A) wherein the angle is chosen to provide a smaller spacing between printing elements relative to the print line. The print head operated in this manner can be for a variety of different printer types, for example, a wire matrix printer or an ink jet printer.



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MULTIPLE MODE PRINTING SYSTEM AND METHOD

Description

Technical Field of the Invention

This invention relates to devices for printing data. More particularly, this invention is directed to a technique for providing at least two degrees of printing quality, at different speeds, with a printer utilizing a matrix print head.

Background Art

Representative of the closest known prior art are Patent US -A- 4,031,992; IBM Technical Disclosure Bulletin, "PRINTER TRANSPORT MOTION IMPEDIENT PROTECTION", Vol. 22, No. 6, pages 2433 - 35 (November, 1979);IBM Technical Disclosure Bulletin, "WIRE PRINTER", Vol. 22, No. 4, pages 1589 - 92 (September, 1979); IBM Technical Disclosure Bulletin, "INK JET HEAD", Vol. 20, No. 2, pages 553 - 54 (July, 1977).

The above-cited IBM Technical Disclosure Bulletin entitled "PRINTER TRANSPORT MOTION IMPEDIENT PROTECTION" shows a representative example of a prior art matrix printer. In this type of printer a matrix print head includes a plurality of printing elements arranged in one or more straight lines. This line of printing elements is mounted on a head carrier for lateral movement across a print line. A printing medium, for example, paper, is positioned so that an images can be selectively imparted from the individual printing elements relative to the paper as the line of printing elements is laterally moved across a desired print line on the paper. Fig. 2 of this article shows a block diagram of the control circuitry necessary to coordinate the energization of the individual printing elements with the lateral position of these elements along the print line

so that the appropriate images of the characters are made to appear on the printing medium. The printing technology suggested in this article is that of wire matrix impact printing although the principles of synchronizing the lateral movement of a plurality of printing elements arranged in a line with the activation of these elements for printing is equally applicable to other printing technologies, for example, ink jet printing or electro-erosion printing.

In matrix printers of this type there are sometimes print quality problems associated with the fact that the printed characters are comprised of a number of graphical elements in the forms of dots or the like as compared with continuous straight and curved lines produced by other, prior art printing techniques, such as standard typewriters. The IBM Technical Disclosure Bulletin article entitled "WIRE PRINTER" shows a side view of a wire matrix print head in Fig. 2 thereof. From this drawing and, also, Fig. 1 of the IBM Technical Disclosure Bulletin article mentioned above, it will be understood that problems exist in packaging a wire matrix print head such that the wires are close enough together to provide printed characters appearing to consist of continuous lines.

The IBM Technical Disclosure Bulletin article entitled "INK JET HEAD" shows a configuration in Fig. 1 thereof in which an ink jet print head includes two separate columns of printing elements with the printing elements in one column being staggered relative to the printing elements in the other column. Lateral movement of this arrangement across a print line makes possible the composition of characters having the graphical elements thereof spaced more closely together, for higher print quality, than might be possible with a single column of printing elements.

Closely associated with the approach immediately described above to achieve higher printing quality is the use of a single column of spaced printing elements in conjunction

with more than one pass along the print line with the paper being indexed slightly before each successive pass of the print head to provide characters comprising more graphical elements in the vertical axis portions than the number of printing elements in the single column of printing elements of the printing head. With this approach, however, the printing throughput can be severely reduced by the necessity of more than one pass of the print head across the print line per line of characters printed.

In many applications, of course, it is not necessary to achieve particularly high printing quality. This is especially so when printing quality is compared with speed of printing as described in the prior art example above. Thus, when printing is for the purpose of generating rough draft material that will be printed at least one more time before formal distribution, it is generally more important to print the material in easily readable form, as quickly as is reasonably possible, without introducing delays to improve upon the quality of the printing. On the other hand, after all of the editing and revision has taken place to generate a final document it is often desirable to sacrifice some speed in printing to produce a higher print quality in the final document.

To the extent that alphanumeric characters having different shapes might be thought to be characters of different quality, patent US -A- 4,031,992 shows a wire matrix print head that is capable of a slight degree of rotation such that in a first vertical position a character such as a E is printed with its vertically oriented line substantially perpendicular to its horizontally oriented lines. In a second position of the print head the line of printing wires is rotated slightly off of the vertical axis so that the vertically disposed line on the E is slanted such that an angle of less that 90° exists between this vertically disposed line and the bottom horizontal line of the E. No other difference in printing quality appears to be suggested by this patent. That is, in the examples shown of the

straight and slanted versions of the E, the same number of graphical elements are used in constructing each of the versions. Thus, the apparent lines forming the characters made up by the dots printed by the wires have no more of a continuous appearance in the slanted E as compared with the other E or vice versa.

It would, therefore, be advantageous to utilize the unique printing technique of this invention which provides a selectable choice in the printing quality to allow a relatively high speed draft mode of printing or a higher quality, final mode of printing at reduced speed, subject to the operator's choice.

Brief Description of the Invention

Accordingly, the print head of a matrix printer is mounted for lateral movement along a desired print line at more than one angle of the printing elements of the head relative to the print line. In a draft mode of operation the angle is chosen to provide a greater spacing between the printing elements of the head relative to the print line than is realized in a final mode of printing wherein the angle is chosen to provide a smaller spacing between printing elements relative to the print line.

The printing technologies to which the invention is applicable includes wire matrix printing and ink jet printing as two examples. In one of the preferred embodiments a single column of printing elements is disposed at a 90° angle relative to the desired printing line. As the head is swept across the paper two lines of characters are printed on the paper with a predetermined few of the printing elements of the head being inactive to provide vertical spacing between the printed lines. This is the draft mode of operation and relatively high speed is realized by printing two lines at a time. The vertical spacing between the printing elements is relatively large so that the characters appear to be constructed of a plurality of dots

or other shaped graphical elements rather than continuous lines. However this fact is not particularly objectionable in the draft mode wherein high printing speed is realized by printing two lines with each single lateral sweep of the head across the paper. In a second, or final quality, printing mode the single line of printing elements is rotated to a position at which the entire plurality of printing elements is used to print only one line of characters at a time. All of the printing elements are utilized, including the ones that were inactive in the draft mode to provide space between the two printed lines. This provides much higher quality printing because the character elements of which the printed characters are composed are spaced much more closely together in the vertical axis. This provides a printing quality much more closely associated with that of printing technologies in which characters are composed of continous segments of straight and curved lines.

In another of the preferred embodiments the print head includes two parallel columns of printing elements with the printing elements of one column being staggered relative to the printing elements of the other column. When the print head is moved laterally across the print line perpendicularly thereto, the apparent vertical axis spacing of the graphical elements of which the character is composed appears to be substantially half the spacing of the printing elements in either of the columns. This is the final mode of printing with this type head, and high quality printing is realized although the printing elements of each column must be activated twice to produce each vertically oriented line in the character, which reduces the printing speed. For the draft mode of operation the head is rotated to an angle such that each of the printing elements in one column is horizontally disposed from a printing element in the other column. In this mode the head can be swept laterally across the page at a higher printing speed by alternating use of adjacent printing elements and allowing speeds that are a multiple of the maximum repetition rate of a single

printing element although the printed characters produced are substantially smaller than the characters produced in the final mode with this head configuration.

The foregoing and other objects, features, extensions, and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawing.

Brief Description of the Drawing

Fig. 1 shows a view of the end of a matrix print head of the type used with the present invention.

Fig. 2 shows a matrix print head of the type shown in Fig. 1 positionable in either a draft quality or a final quality printing mode.

Fig. 3 shows an alternative print head configuration positionable in either a draft quality or a final quality printing mode.

Fig. 4 shows a print head mounting arrangement adapted for movement of the printing elements at more than one angle relative to the print line.

Description of the Preferred Embodiments

Referring now to Fig. 1, the end of a matrix print head 1 is shown. The print head may be a wire matrix print head, an ink jet print head, or the printing head of any type printer in which individual printing elements are used to impart a plurality of graphical elements onto a medium to construct images such as alphanumeric characters. For descriptive purposes throughout the remainder of this description it will be assumed that the print head 1 is of the wire matrix type although the invention, of course, is not so limited.

The individual printing elements of the print head 1 are the print wires 2 through 8. While seven wires are shown for the purposes of illustration in Fig. 1 it will, of course, be understood that any number of wires may be used to produce characters of various size and quality. The spacing between the wires in the vertical axis is shown as dV. To print a character on paper with this type print head an ink ribbon (not shown) may be interposed between the head 1 and the paper. Head 1 is then moved laterally in the direction indicated by the arrow X and the individual printing elements 2-8 are selectively energized in synchronization with this movement to produce a plurality of graphical elements in the form of dots, or the like, to construct the character. In Figs 1 - 3 the character "F" is shown for illustrative purposes, as it would appear after lateral movement of the print head along the X axis. In Fig. 1 the printing elements are activated during this lateral movement of head 1 such that the horizontal spacing dH between printed graphical elements is substantially equal to dV. However, dH may vary over a wide range and is a function of the character to be printed and is controlled by printing element actuation timing. Thus, dH = dV is not a requirement.

Fig. 2 shows a matrix print head of the type shown in Fig. 1 which is positionable in accordance with this invention to provide either a draft quality or a final quality printing mode. The print head 9 includes the 20 printing elements 10 - 29. In a draft mode position of print head 9 the angle between the printing line axis across which head 9 is moved in a lateral direction as indicated by the arrow X is substantially perpendicular. Thus, with the 20 printing elements shown the printing of two print lines, each having a height b, are possible during each lateral pass of print head 9 across the printing medium. Eight of the 20 printing elements are used in printing each of these two lines and four of the printing elements are unused in the draft mode position to provide a spacing h between the two print lines. With the horizontal distance between

printed graphical elements being maintained the same as the vertical distance between printed graphical elements, characters may be printed in each of the two lines having the quality of the F shown as an example in the upper left portion of Fig. 2. This is a high speed printing mode, because two lines are printed during each lateral pass of the print head 9.

In Fig. 2 the print head is shown rotated into a final mode position as indicated by 9A. An example of the F printed in this mode is shown in the upper right portion of Fig. 2, wherein the horizontal distance between printed graphical elements is maintained equal to the new vertical distance between printed graphical elements. It is readily apparent that the quality of the characters obtainable with the print head in this position is far superior to the quality of the characters shown with the print head rotated back through the angle A so that it is perpendicular to the print line in the draft mode position. It will also be apparent that since the print head 9A in the final mode position only prints one line of characters per lateral pass along the print line the speed at which a page of N lines may be printed in the final mode position is, at most, only one-half the speed at which a page of N lines may be printed in the draft mode position. The speed in the final mode position may be reduced below one-half by the fact that it may be necessary to laterally sweep the print head at a lower rate across the print line depending on the rate at which the printing elements may be activated to print the graphical elements on the paper.

Referring now to Fig. 3 an alternate embodiment of the invention is shown wherein a print head 30 is comprised of two parallel columns of printing elements. A first column includes the eight printing elements 31 - 38 and the second column includes the eight printing elements 41 - 48. The second column is downwardly displaced by half the distance between the printing elements so that as the print head 30 is swept laterally across the print line in the X

axis the printing elements of the two columns may be sequencially activated to produce lines such as those shown in the F adjacent print head 30. In the embodiment of Fig. 3 the print head 30 is positioned in the final printing mode when the print head is substantially perpendicular to the print line or X axis.

Rotation of the print head through angle B positions the print head, now designated 30A, for printing in the draft mode. In this mode pairs of printing elements of different columns are aligned parallel to the print line or X axis so that the apparent distance between the printing elements becomes much greater on the print line than when the print head is in the final mode position. Instead of 16 printing elements being useable in the vertical axis in the final mode position, the draft mode position of print head 30A has only eight printing elements useable in this mode. It will also be noted that the F printed in the draft mode position is substantially smaller than the F printed in the final mode position. The printing speed, however, can be substantially greater in the draft mode position because the printing elements can be alternately operated such that the apparent repetition rate of the elements is twice as great as if a single column of elements were operated in this manner.

Fig. 4 shows a schematically embodiment of a matrix print head 50 mounted on a matrix print head carrier 51. Carrier 51 is slideably moveable along a rail 52 as indicated by the arrow X. The print lines are also printed in the direction indicated by X. Print head 50 is pivotally mounted to carrier 51 at pivot 53. A head pivoting mechanism 54 is rigidly mounted to the head carrier 51 by a suitable structure 55. Mechanism 54 is electromechanically or mechanically operable to engage rod 56 having one end thereof connected at pivot 57 to head 50. Movement of rod 56 relative to mechanism 54 causes a pivoting motion of head 50 about pivot 53 to cause the head 50 to assume various angles, other than that shown, relative to the

print line. Fig. 4 shows this arrangement for exemplary purposes only, it being understood that the particular arrangment to pivot the print head for the multiple modes of operation may take a variety of forms each depending on the particular printing technology to which this invention is applied.

In summary, a printing technique has been shown using a single matrix print head including a plurality of printing elements arranged in one or more straight lines and mounted for lateral movement across a print line at more than one angle. In a draft mode of operation the angle is chosen to provide a greater spacing between printing elements relative to the print line than is realized in the final or higher quality mode. Various embodiments of the invention have been shown including one embodiment wherein a single column of printing elements is utilized for printing more than one line at a time in the draft mode and a single line at a time in the final mode. In another embodiment a printing element includes a plurality of parallel columns of printing elements with the columns staggered in the vertical axis to increase the density of printable graphical elements on the paper. The print head is rotatable from a final mode position substantially perpendicular to the print line to a draft mode position in which the parallel columns of printing elements are positioned relative to the print line such that one printing element in each column is aligned horizontally relative to a printing element in each of the other columns. In this position a draft mode quality is realizable with a different size print character than that obtained in the final mode position.

While the invention has been shown and described with reference to particular embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and detail may be made therein without departing from the spirit and scope of the invention. For example, a combination of the arrangements shown in Figs. 2 and 3 could be utilized or any other configu-

ration could be utilized to provide a substantially different quality of printed characters as well as the realization of a higher printing speed in one mode as compared to the other printing mode.

CLAIMS

1.- Printing system comprising:

an array of selectively actuable printing elements arranged in one or more columns mounted for movement along a first axis relative to a printing medium, characterized in that it comprises:

means for positioning said array in a draft mode position for causing a first spacing between said printing elements relative to a second axis substantially perpendicular to said first axis; and

means for positioning said array in a final mode position for causing a second spacing substantially less than said first spacing between said printing elements relative to said second axis.

2.- Printing system according to Claim 1 characterized in that said means for positioning said array in said draft mode includes means for positioning columns of said array substantially parallel to said second axis.

3.- Printing system according to Claim 1 or 2 characterized in that said means for positioning said array in said final mode includes means for positioning columns of said array at a sufficient angle from said second axis for causing said second spacing to be no greater than one-half of said first spacing.

4.- Printing system according to Claim 1, 2 or 3 characterized in that the printing elements are arranged in a purality of columns so that the printing elements of each column are staggered relative to the printing elements of the next columns and so that a plurality of rows can be formed each row including a single printing element from each of said plurality of columns.

5.- Method of printing characters, comprising:

arranging a plurality of printing elements in an array arranged in one or more columns;

mounting said array for movement across a first axis relative to a printing medium;

characterized in that it comprises:

positionning said array in a draft mode position for causing a first spacing between said printing elements relative to a second axis substantially perpendicular to said first axis;

selectively actuating said printing elements during movement of said array across said first axis to cause printing of characters on said printing medium;

positionning said array in a final mode position for causing a second spacing substantially less than said first spacing between said printing elements relative to said second axis;and

selectively actuating said printing elements during movement of said array across said first axis to cause printing of characters on said printing medium.

6.- Method of printing characters, according to Claim 5 characterized in that it comprises:

in the draft mode position, selectively actuating said printing elements during movement of said array across said first axis to cause printing of characters on said printing medium in X lines of characters at a time, X being greater than one;

and in the final mode position, selectively actuating said printing elements during movement of said array

across said first axis to cause printing of characters parallel to said first axis on a number of print lines less than X.

7.- Method of printing characters according to Claim 5 or 6 characterized in that one of said steps of positioning said array includes positioning said columns of said array substantially parallel to said second axis.

8.- Method of printing characters according to Claim 5, 6 or 7 characterized in that the array includes a plurality of columns substantially parallel to each other.

9.- Method of printing characters according to Claim 8 characterized in that it further comprises arranging said plurality of columns of printing elements so that printing elements of each column are staggered relative to the printing elements of the next columns.

10.- The method of printing characters according to Claim 9 characterized in that one of said steps of positioning said array includes positioning said plurality of columns at a sufficient angle from said second axis for causing a plurality of rows of printing elements to be formed, each row being parallel to said first axis and each row including a single printing element from each of said plurality of columns.

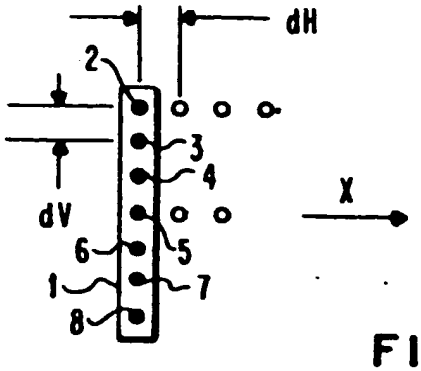
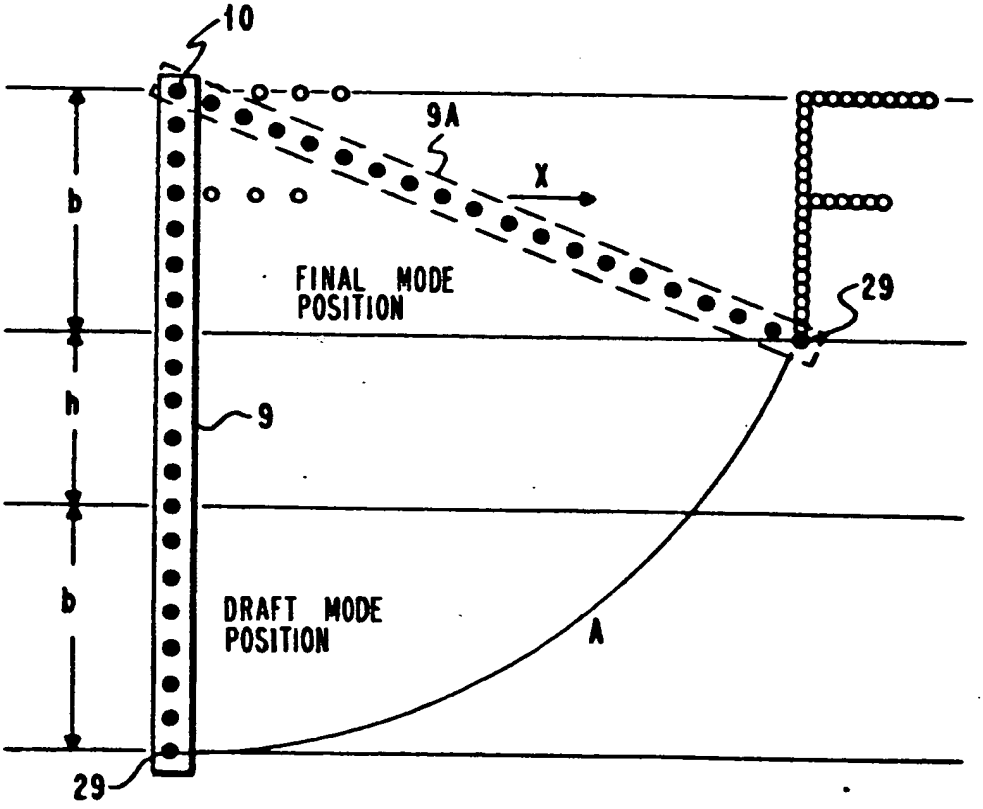

dH
2
3
4
dV
X
6
5
1
7
8

FIG. 1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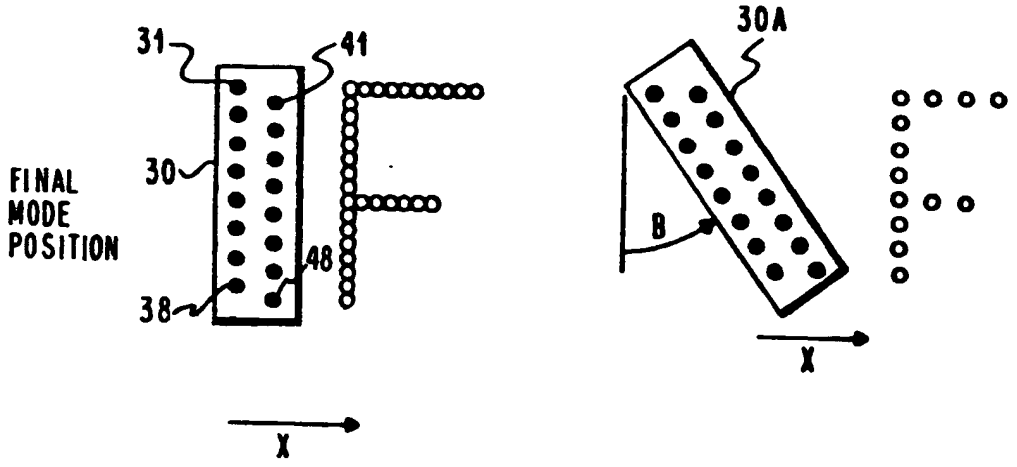
DRAFT MODE
POSITION
A
29

FIG. 2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B
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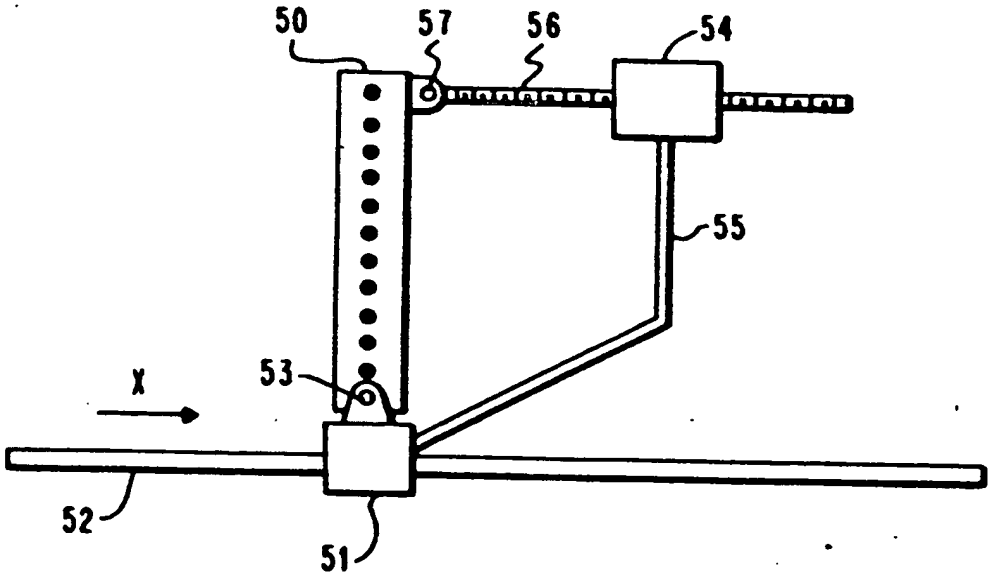
FIG. 3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57
56
54
55
53
X
52
51

FIG. 4